# TERTIARY FLUVIAL SEDIMENTS AT MORRISON, VICTORIA

By Paul Bolger

Geological Survey of Victoria, 107 Russell Street, Melbourne, Victoria, 3000

(*Present Address*: Herman Research Laboratory, State Electricity Commission of Victoria, Howard Street, Richmond, Victoria 3121)

Abstract: Tertiary fluvial sediments underlying the Newer Volcanics in the Morrison area, Victoria, are subdivided into two units. The basal Ballark Conglomerate is very coarse grained, consisting of locally derived Ordovician bedrock clasts. Originally considered to be of Permian age its conformable relationship to the overlying 'Sub-basaltic sediments' suggests a Tertiary age. The 'Sub-basaltic sediments' grade vertically from the Ballark Conglomerate, are finer grained and contain abundant vein quartz and subordinate Ordovician sandstone clasts. Extensive areas of the sediments have been silicified. Clasts of the silcrete occur in the upper beds of the 'Sub-basaltic sediments', enabling subdivision into an upper and lower unit. Palaeocurrent analyses in the Ballark Conglomerate and the basal beds of the 'Sub-basaltic sediments' and examination of the distribution of Newer Volcanic flows in this area and further west, suggest a major drainage reversal from northward to southward prior to basalt extrusion.

## INTRODUCTION

Tightly folded Ordovician bedrock is overlain by flat-lying Tertiary conglomerate, gravel, sand, silt and clay and basalts of the Newer Volcanics in the Meredith-Morrison-Elaine area. The area is located within an elevated block of Lower Palaeozoic bedrock that is marginal to the Tertiary Otway and Port Phillip Basins and the 'Ballan Graben' (Fig. 1).

The Tertiary sequence is subdivided into a thick, massive basal conglomerate, named the Ballark Conglomerate (Bolger 1977), and an overlying unit of interbedded gravel, sand, silt, clay and rare tuff referred to informally in this paper as 'the Sub-basaltic sediments'. These units are exposed along the valleys of the Moorabool River and Tea Tree Creek at Morrison (Fig. 1). Selwyn and Ulrich (1866), Brough-Smyth (1869), Dunn (1907), Hunter (1909), Harris and Thomas (1949), Makram and Neilson (1970) and Jahnke (1973) all referred to the massive conglomerate at Morrison, but it was never described in detail. The purpose of this paper is to describe the Ballark Conglomerate and the overlying sediments and to discuss their age, and depositional environment.

## BALLARK CONGLOMERATE

The Ballark Conglomerate (Bolger 1977) is a coarse grained deposit, cropping out along the valleys of the Moorabool River and Tea Tree Creek and exposed in a water race on the slopes leading down to Dolly's Creek at Morrison (Fig. 1). It is also known from bores and mine workings in the area. The type locality of the Ballark Conglomerate is the exposure on the south side of the valley of Tea Tree Creek (Grid reference 166.393, Meredith 1:63 360 map).

The Ballark Conglomerate (Fig. 3) is a poorly sorted orthoconglomerate with a maximum observed clast diameter of 1 m and a median maximum diameter between 10 and 15 cm. The framework consists of 70% arenaceous clasts (quartzitic sandstone and greywacke), 15% slate and siltstone and 15% quartz. Sandstone and quartz cobbles and boulders are rounded to well rounded and tend to be ellipsoidal. Slate casts are platey, often have rounded edges and are strongly imbricated. Quartz pebbles are usually equant and subrounded. The matrix consists of angular to subangular, coarse to very coarse sand and granule gravel consisting of quartz, muscovite and deeply weathered, platey, slate clasts weakly bound by interstitial clay and silt. The Ballark Conglomerate is usually friable, although 3.5 km north of Morrison along the east bank of the Moorabool River, the clasts are closely compacted and cemented by limonite. It is massive and homogeneous and apart from trough-crossbedded coarse-sand lenses up to 0.5 m thick, bedding is not recognisable. Along the Moorabool River, exposures of the conglomerate are up to 30 m high and at the type locality are 8 m high. Selwyn and Ulrich (1866) recorded about 120 m of 'Miocene gravel' from Tea Tree Creek. Brough-Smyth (1896) recorded a thin basal unit comprising gravel, black clay containing fossil trees and grey sandy clay containing gold, overlain by more than 100 m of conglomerate in the Golden Rivers mine along Tea Tree Creek. This basal unit is not exposed but is here included in the Ballark Conglomerate.

The base of the Ballark Conglomerate is not exposed but it overlies Ordovician bedrock along Tea Tree Creek (Brough-Smyth 1869). In the Borhoneyghurk 1 bore near Morrison 135 m of conglomerate rests on Ordovician bedrock. The basal 35 m contains granite boulders, up to 1.5 m in diameter, which may be glacial erratics. The basal 35 m is thus inferred to be of glacigene origin, and excluded from the Ballark Conglomerate. Although the contact between the Ballark Conglomerate and the Ordovician bedrock is not exposed, outcrops along the Moorabool River suggest a sharp, steep boundary and a high angular unconformity is inferred. The Conglomerate grades into the overlying sub-basaltic sediments with a decrease in the percentage of slatey clasts. The top of the Ballark Conglomerate is taken to be the uppermost bed of coarse conglomerate containing sandstone, quartz and more than 8% slatey clasts.

## SUB-BASALTIC SEDIMENTS

Up to 40 m of terrigeneous sediments comprising poorly consolidated interbedded gravel, sand, silt, clay and rare tuff underlie the Newer Volcanics along the Moorabool River and Tea Tree Creek and are known from the bores between Morrison and Elaine. To the east and west of Morrison, silicified quartz gravel and sand forms part of an extensive plateau (Fig. 1). Ferruginous sands and gravels occur north of Morrison.

The gravels consist mostly of quartz clasts with smaller amounts of sandstone, slate and siliceous sandstone and conglomerate. Quartz pebbles are usually less than 10 cm in diameter and occur either as equant, subangular to rounded, or as well rounded, platey and rodlike grains. Platey clasts are imbricated. Sandstone and silcrete clasts are usually less than 10 cm in length and are well rounded and ellipsoidal. The coarsest beds are at the base of the unit, where there are well rounded cobbles and pebbles of sandstone and quartz up to 30 cm in length (Fig. 4). Fine to medium grained cross-bedded and horizontally-bedded sand, pebbly sand, clayey sand, silt and clay are interbedded with the gravel. Sand beds are composed almost exclusively of common ('plutonic') quartz. Massive silt and clay units are up to 15 m thick. A 1 m thick planar-laminated tuff band exposed on the Moorabool River about 5 km north of Morrison consists largely of subangular quartz and plagioclase sand grains and pebbles of basalt in a clayey matrix.

The sub-basaltic sediments, at least in part, are considered to conformably overlie the Ballark Conglomerate. Locally the base of the sub-basaltic beds is transitional with the underlying Ballark Conglomerate, and comprises massive homogeneous pebble to cobble conglomerate, containing coarse sandstone and quartz but rare to absent slate or siltstone clasts. The basal coarse units grade vertically into interbedded gravel, sand, silt and clay (Fig. 4). The decrease in grain size is accompanied by a decrease in the number of lithic clasts.

Silcrete clasts do not occur in the Ballark Conglomerate, the transitional gravels at the base of the sub-basaltic sediments, nor in the silcretes on either side of the Moorabool River, but they are present in the upper beds of the sub-basaltic sediments. This suggests the existence of two units within the sub-basaltic sediments (Fig. 2), although the sparsity of silcrete clasts in the sediments makes detailed mapping difficult. It is suggested that a period of silcrete formation took place between deposition of the lower and upper units of the sub-basaltic sediments and that the upper unit disconformably overlies the lower. The duration of this break in deposition is not known.

## PALAEONTOLOGY AND AGE

### Ballark Conglomerate

The age of the Ballark Conglomerate has been disputed for many years. Dunn (1907), Kenny (1937), Harris and Thomas (1949) and Makram and Neilson (1970) considered the Ballark Conglomerate to be of Permian age. Harris and Thomas (1949) inferred a Permian age largely on the basis of large granite boulders in the basal 35 m of the Borhoneyghurk 1 bore. The abundance of slatey clasts in the Ballark Conglomerate gives it a similar appearance to Permian glacigene conglomerates in the Ballan and Bacchus Marsh areas to the north of Morrison. However, the wide variety of erratics recorded in the Permian beds (Bowen & Thomas, 1976) is not found in the Ballark Conglomerate, nor are faceted or striated pebbles. There is therefore no direct evidence in the exposures at Morrison to suggest either a glacial origin or a Permian age for the Ballark Conglomerate.

Selwyn and Ulrich (1866) and Brough-Smyth (1869) regarded the Ballark Conglomerate as Miocene, underlying Pliocene auriferous gravels and Newer Basalt. Hunter (1909, p. 116) concluded that 'the presence of large boulders and fossil logs tend to show that this material is of early Tertiary age'. The conformable relationship with the Tertiary sub-basaltic sediments establishes a Tertiary age for the Ballark Conglomerate.

No megafossils have been collected from the Ballark Conglomerate, but plant spores have been recovered from one sample of the conglomerate matrix in the top 5 m outcropping on the north side along Tea Tree Creek. The samples contained very few species but included a single specimen of *Tubuliforidites antipodica* which suggests a late Miocene age (*Triporopollenites bellus* Zone) (D. T. Ripper, V. Archer pers. comm. 1978). However, the micro-flora is not diagnostic and the precise age of the Ballark Conglomerate is still uncertain.

A basaltic tuff overlying the conglomerate contains clasts of basalt which resemble the early Miocene Maude Basalt, exposed 17 km south of Morrison (Bowler 1963), rather than the Older Volcanics of the Ballan Graben or the Newer Volcanics within the Morrisons area (R. A. Day pers. comm. 1981). The presence of these clasts supports the notion that the Ballark Conglomerate and the basal beds of the sub-basaltic sediments are of Early to Middle Tertiary age.

### Sub-Basaltic Sediments

The sub-basaltic sediments contain rare indeterminate compressions of fossil wood, but there are no palaeontological data to determine their precise age. However, similar sediments which are intimately associated with the Plio-Pleistocene Newer Volcanics throughout Victoria are customarily regarded as Pliocene (Abele *et al.* 1976) and are probably older in some areas. Thomas and Baragwanath (1950) partly equated gravel, sand and clay underlying the Newer Volcanics with the Rowsley Formation, in which they include sandy sediments overlying the brown coal in the Maddingley No. 1 Open Cut at Bacchus Marsh. The upper part of the sub-basaltic sediments at Morrison is considered to be partly equivalent to the Rowsley Formation. The basal beds

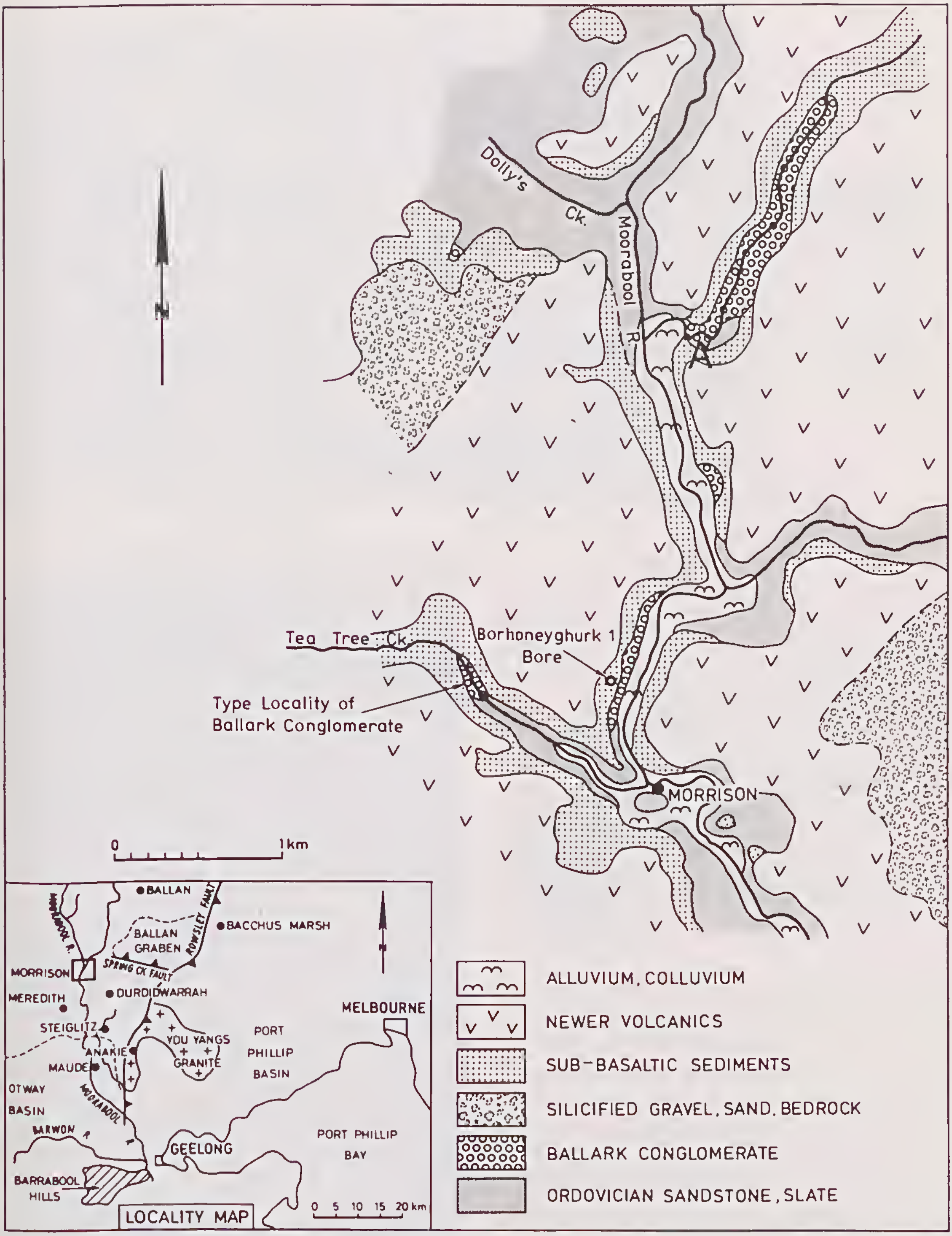


Fig. 1 – Geological map of the Morrison area. A marks site of section A of Fig. 2 and section B is at and in the vicinity of Borhoneyghurk No. 1 Bore.

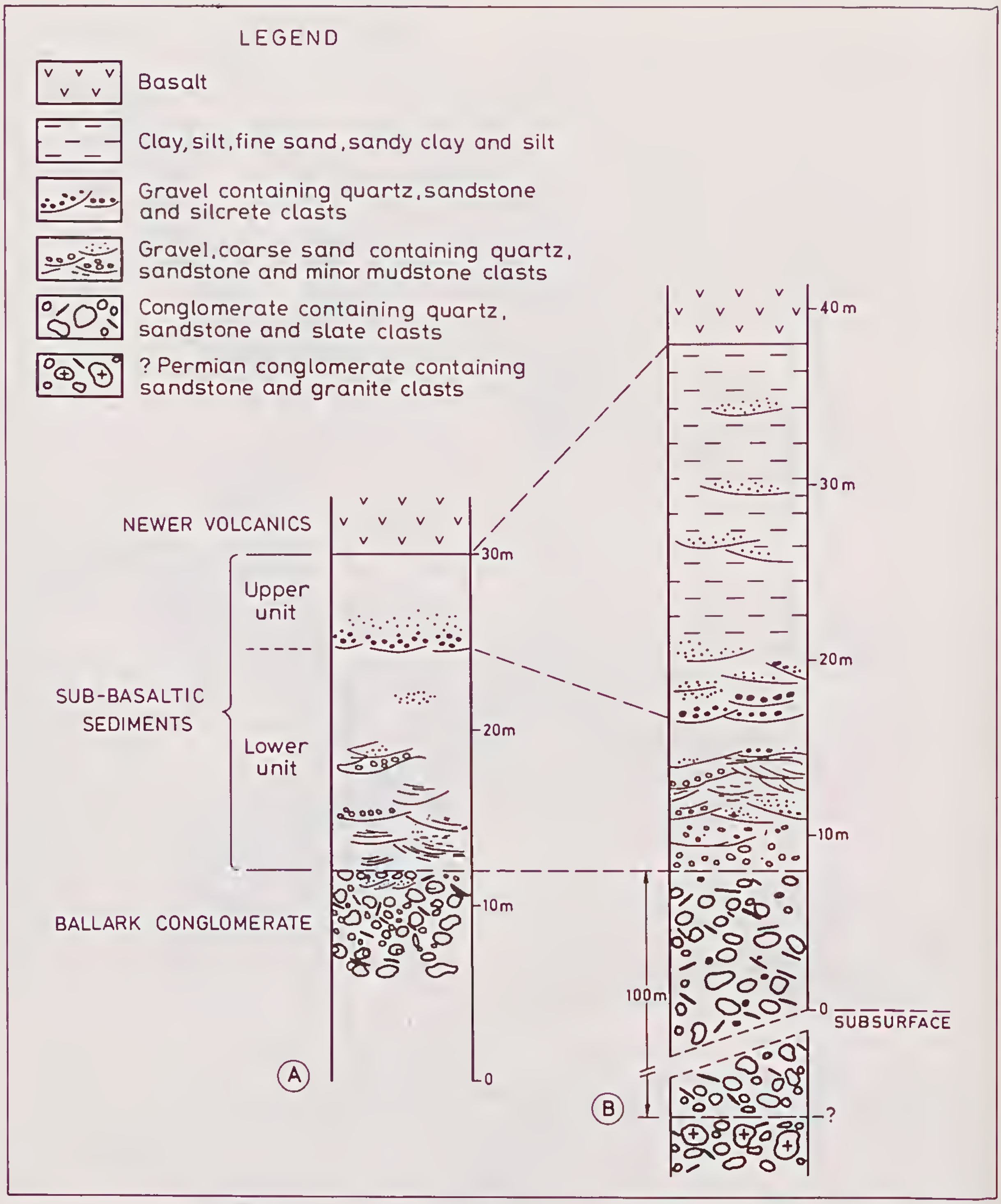


Fig. 2—Columnar sections of Tertiary rock units located on Fig. 1.

may be considerably older, perhaps Early to Middle Tertiary.

## LITHOFACIES AND DEPOSITIONAL ENVIRONMENT

Poor exposure along the Moorabool River and Tea Tree Creek does not allow detailed facies analysis of the Tertiary sediments. However, 8 lithofacies are recognised in the sediments at Morrison and are briefly described below. Lithofacies nomenclature is after Miall (1977).

Fig. 3 — Poorly sorted Ballark Conglomerate, Tea Tree Creek, Morrison.

Fig. 4 — Basal units of Sub-basaltic sediments showing fining upward into interbedded gravel and sand.

### Lithofacies Types

Lithofacies *Gm(bc)* comprises the coarse, poorly bedded and sorted, clast supported conglomerate of the Ballark Conglomerate. Platey clasts are strongly imbricated. Individual depositional units are generally unrecognisable although there are very rare trough cross-bedded coarse-sand lenses up to 1 m thick (Fig. 5).

Lithofacies *Gm(sb)* comprises the coarse cobble to pebble, upward fining conglomerates in the sub-basaltic sediments. Imbricated pebbles are present but less abundant in this lithofacies than in lithofacies *Gm(bc)* due to the smaller number of slate clasts. Individual units are 1-2 m thick (Fig. 4).

Trough cross-bedded gravels ranging from granule to pebble size comprise lithofacies *Gt*. Individual troughs with theta cross-bedding are up to 1 m deep. Gravel bands have erosional bases and thin lenticles of clay and silt are common.

Lithofacies *St* comprises trough cross-bedded very coarse sand with intercalated lenses of granule gravel up to 0.5 m thick. Troughs are generally less than 1 m deep. The sands are often clayey.

Units of horizontally bedded medium sand less than 1 m thick comprise lithofacies *Sh*, and planar cross-bedded coarse sands with individual sets up to 0.7 m, comprise lithofacies *Sp*. These occur locally in the sub-basaltic sediments.

Lithofacies *Fm* occurs in both the Ballark Conglomerate and the sub-basaltic sediments and comprises structureless clay, silt, silty and sandy clay, carbonaceous clay containing some plant remains and very thin gravelly bands. It occurs at the base of the Ballark Conglomerate (Brough-Smyth 1869) but is not exposed and is known only from old mining records. In the sub-basaltic sediments it occurs in thin units interbedded

Fig. 5—Trough cross-bedded sand in top 2m of Ballark Conglomerate, Moorabool River, Morrison.

with gravel and sand and also in thick units up to 15 m thick on the west bank of the Moorabool River.

## Lithofacies Distribution and Interpretation of Depositional Environment

Three lithofacies assemblages are recognised, one in the Ballark Conglomerate and two in the sub-basaltic sediments.

Assemblage 1 comprises lithofacies *Gm(bc)*, rarely *St* and *Fm* at the base and is restricted to the Ballark Conglomerate. This assemblage is characteristic of deposits accumulated by superposition of longitudinal bars in gravel rivers (Miall 1977).

Assemblage 2 comprises the lithofacies *Gm(sb)*, *Gt*, *St*, *Sh*, *Sp* and *Fm* and is restricted to the sub-basaltic sediments. Lithofacies *Gm(sb)* appears to be common at the base of the sub-basaltic sediments and comprises much of the transition zone overlying the Ballark Conglomerate. Assemblage 2 contains graded cycles with basal *Gm(sb)* and *Gt* units overlain by *St* or less commonly *Sp* or *Sh* and sometimes *Fm* units. These cycles are considered to represent channel filling events in gravel streams.

The thick lithofacies *Fm* and locally *St* and *Gm(sb)* comprise Assemblage 3, which occurs within the uppermost beds of the sub-basaltic sediments. This assemblage represents deposition largely under conditions of low flow, with some point bar deposition. Its thickness in this area suggests prolonged deposition of fine sediment from suspension in standing water. The lithofacies represent abandoned channel and overbank deposits.

## PALAEOCURRENT ANALYSIS

Pebble imbrication, determined by measuring the dip direction of the AB plane of platey clasts, was used to infer transport directions for both the Ballark Conglomerate and the basal gravel units of the sub-basaltic sediments. The data are summarised in Fig. 6.

The results suggest that currents depositing both the Ballark Conglomerate and the overlying sub-basaltic

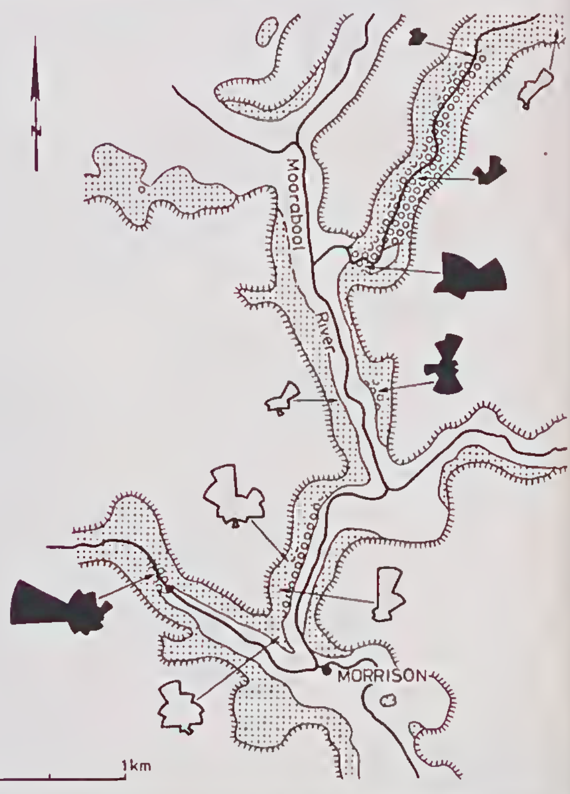


Fig. 6—Summary of palaeocurrent data. Filled roses refer to Ballark Conglomerate. Open roses refer to lower unit, Sub-basaltic sediments.

sediments moved from south to north, implying a drainage divide south of Morrison. This would suggest an uplifted zone to the south of Meredith, with streams transporting detritus into the 'Ballan Graben'. The orientation of poorly exposed trough cross-beds is consistent with transport directions from the south and south-west.

However, this interpretation of the palaeogeography is not consistent with the interpretation of the drainage system based on the distribution of Newer Volcanics in this area, which suggests a southerly palaeoslope. The basalt flows and associated deep leads in the Ballarat-Rokewood area, west of Morrison have southerly trends and flowed between elevated areas of Ordovician bedrock often capped with ferruginised Tertiary sediments. The youngest basalt flow at Morrison was also a valley flow restricted by cappings of silcrete, ferruginous Tertiary sediments and Ordovician bedrock. The modern Moorabool River system north of Morrison, comprising two lateral streams around this basalt flow, is southward flowing and follows the pre-basaltic drainage system.

It is suggested that the drainage system changed from northward flowing streams which deposited the Ballark Conglomerate and lower beds of the sub-basaltic sediments, to a southward flowing system reflected by the distribution of Newer Volcanic flows. It is considered to be largely the result of uplift on the Rowsley and Spring Creek Faults.

A drainage reversal of this type is problematical. There is no topographic evidence to support widespread river capture in the areas to the north of Morrison. Other than the appearance of silcrete clasts in the upper unit of the sub-basaltic sediments, no change in provenance reflected by the petrography of the sediments is recognised above or below the disconformity. However, this is not surprising as the likely source rocks both to north and south of Morrison are Ordovician sandstones, slates and associated quartz veins.

The timing of the inferred drainage reversal is not known, although it may coincide with final marine regression from the Durdidwarrah-Anakie area to the south in the late Miocene-Pliocene (Bolger & Russell in prep.).

The widespread occurrence of silcretes and their possible time relationship to the drainage reversal raises the possibility of silcrete formation resulting from severe alteration of the hydrological system imposed by the drainage reversal. Although spatially related to basalts of the Newer Volcanics, the genetic affinities of the silcretes and basalts are not clearly established (Bolger 1977).

## CONCLUSION

Up to 120 m of coarse grained lithic detritus derived largely from the local Ordovician bedrock was deposited at Morrison to form the Ballark Conglomerate. The high lithic content in the Ballark Conglomerate is atypical of most Tertiary clastic deposits in Victoria and has led to some confusion about its age. However, its conformable relationship with more typical quartzose Tertiary fluvial deposits suggests that the Ballark Conglomerate is Tertiary.

The linear distribution of the Ballark Conglomerate and the nature of the basement topography suggest that it was deposited in a steep-sided narrow channel. The Conglomerate was deposited by a high energy gravel river flowing to the north or north-east. The single narrow channel eventually filled and a more widespread stream system was established. Extensive sheets of gravelly quartzose sediments comprising the basal beds of the sub-basaltic sediments were deposited above the Ballark Conglomerate and the Ordovician bedrock. Current directions remained northward. These deposits and the surrounding Ordovician bedrock were subsequently extensively silicified to form silcrete.

A southward flowing drainage system was initiated, probably in response to movement of the Spring Creek and Rowsley Faults. Incision into the lower units of the sub-basaltic sediments and the Ballark Conglomerate produced terraces. Detritus eroded from the silcrete cappings was deposited by southward flowing streams to form the upper parts of the sub-basaltic sediments at Morrison. Sedimentation at Morrison was terminated by the extrusion of the youngest basalt flow over the sub-basaltic sediments. Lateral streams with deep valleys have subsequently been entrenched.

## ACKNOWLEDGEMENTS

The author thanks Dr J. G. Douglas for encouragement during the course of this investigation and T. G. Russell for constructive criticism of the manuscript. Figures were drafted by Mr G. Held of the S.E.C.V. The work was undertaken and the paper published with the permission of the Director of the Geological Survey of Victoria.

## REFERENCES

Abele, C., Kenley, P. R., Holdgate, G. & Ripper, D., 1976. Otway Basin. *Spec. Publ. geol. Soc. Aust.* 5: 198-229.

Bolger, P. F., 1977. Explanatory notes on the Meredith and You Yangs 1:50 000 geological maps. *Rept. geol. Surv. Vict.* 1977/14.

Bolger, P. F. & Russell, T. G. (in prep). Late Tertiary marine transgression in the Brisbane Ranges, Victoria.

Bowen, R. L. & Thomas, G. A., 1976. Permian. *Spec. Publ. geol. Soc. Aust.* 5: 123-142.

Bowler, J. M., 1963. Tertiary stratigraphy and sedimentation in the Geelong-Maude area, Victoria. *Proc. R. Soc. Vict.* 76: 69-137.

Brough-Smyth, R., 1869. *The goldfields and mineral districts of Victoria.* John Ferres, Govt Printer, Melbourne.

Dunn, E. J., 1907. Geological parish plan, Ballark. *Mines Dept. Melb.*

Harris, W. J. & Thomas, D. E., 1949. Geology of the Meredith area. *Min. geol. J. Vict.* 3: 43-51.

Hunter, S., 1909. Deep leads of Victoria. *Mem. geol. Surv. Vict.* 7.

Jahnke, F. M., 1973. Structural geology of the Morrisons area. BSc (Hons) Univ. Melb. (unpubl).

Makram, A. E. & Neilson, J. L., 1970. Notes on the geology of the Meredith 1:63 360 military sheet. *Rept. geol. Surv. Vict.* 1970/84 (unpubl.).

MIALL, A. D., 1977. A review of the braided river depositional environment. *Earth-Sci. Rev.* 13: 1-62.

SELWYN, A. R. C. & ULRICH, G. H. F., 1866. Notes on the physical geography, geology and mineralogy of Victoria. *Intercolonial Exhibition Essays* 1866-67, 83.

THOMAS, D. E. & BARAGWANATH, W., 1950. The geology of the brown coals of Victoria—Part 3. *Min. geol. J. Vict.* 4: 41-63.